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0001/022

SEP 07 2006

Serial No. 10/736,921
60246-220; 10691**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

Appellant: Wei
 Serial No.: 10/736,921
 Filed: December 16, 2003
 Group Art Unit: 1753
 Examiner: Mayekar, Kishor
 Title: MULTI-LAYERED PHOTOCATALYST/THERMOCATALYST
 FOR IMPROVING INDOOR AIR QUALITY

Mail Stop Appeal Brief- Patents
 Commissioner for Patents
 P.O. Box 1450
 Alexandria VA 22313-1450

APPEAL BRIEF

Dear Sir:

Subsequent to the filing of the Notice of Appeal on July 7, 2006, Appellant hereby submits its brief. The Commissioner is authorized to charge Deposit Account No. 03-0835 in the name of Carrier Corporation \$500.00 for the appeal brief fee. Any additional fees or credits may be charged or applied to Deposit Account No. 50-1482 in the name of Carlson, Gaskey & Olds, P.C.

REAL PARTY IN INTEREST

The real party in interest is Carrier Corporation, the assignee of the entire right and interest in this Application.

RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences.

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60246-220; 10691**STATUS OF CLAIMS**

Claims 1-35 are pending in this application. Claims 30 and 33 stand finally rejected under 112, first paragraph and 112, second paragraph. Claims 1-35 stand finally rejected under 103(a).

STATUS OF AMENDMENTS

All amendments have been entered.

SUMMARY OF CLAIMED SUBJECT MATTER

As shown in Figure 1, this invention relates to a purification system 10 including a substrate 28 and a layered catalytic coating 40 applied on the substrate 28 (page 5, lines 9-16). The layered catalytic coating 40 includes a first layer 42 of a photocatalytic coating, a second layer 44 of a photocatalytic metal loaded metal compound coating, and a third layer 46 of a thermocatalytic coating (page 5, lines 19 to 28, page 6, lines 27 to 30 and page 8, lines 7-11). This basic structure is set forth in Independent Claim 1.

Dependent claim 3 depends on claim 2 and adds that the first layer 42 is a metal compound loaded titanium dioxide coating, and the metal compound is at least one of WO_3 , ZnO , CdS , $SrTiO_3$, Fe_2O_3 , V_2O_5 , SnO_2 , $FeTiO_3$, PbO , Co_3O_4 , NiO , CeO_2 , CuO , SiO_2 , Al_2O_3 , Cr_2O_3 , and ZrO_2 (page 6, lines 23 to 27). Dependent claim 13 depends on claim 1 and adds that the third layer 46 is applied on the substrate 40, the second layer 44 is applied on the third layer 46, and the first layer 42 is applied on the second layer 44 (page 6, lines 22 to 28 and page 8, lines 7 to 11).

Independent claim 22 recites a fluid purification system including a container 10 having an inlet 12 and an outlet 36, a porous substrate 28 inside the container 10, and a device 34 for drawing a fluid into the container 10 through the inlet 12, flowing the fluid through the porous substrate 28, and expelling the fluid out of the container 10 through the outlet 36 (page 5, lines 9 to 16). A layered catalytic coating 40 is applied on the substrate 28, and the layered catalytic coating 40 includes a first layer 42 of a photocatalytic metal oxide coating, a second layer 44 of a photocatalytic noble metal loaded metal oxide coating, and a third layer 46 of a thermocatalytic coating, and the third layer 46 is

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gold/metal oxide (page 5, lines 19 to 28, page 6, lines 27 to 30 and page 8, lines 7-11). An ultraviolet light source 32 activates the layered catalytic coating 40, and photons from the ultraviolet light source 32 are absorbed by the layered catalytic coating 40 to form a reactive hydroxyl radical, and the reactive hydroxyl radical oxidizes contaminants in the fluid that are adsorbed onto the layered catalytic coating 40 when activated by the ultraviolet light source 32 to water and carbon dioxide in the presence of water and oxygen (page 5, lines 29 to 31 and page 6, lines 1 to 4).

Independent claim 24 recites a purification system 50 including a first substrate 52 having a first coating of one of titanium dioxide and metal compound/titanium dioxide, a second substrate 54 having a second coating of metal/titanium dioxide, and a third substrate 56 having a third coating of metal oxide/titanium dioxide (page 10 line 24 to page 11 line 5).

Independent claim 28 recites a method of purification including the steps of applying a layered catalytic coating 40 on a substrate 28, wherein the layered catalytic coating 40 includes a first layer 42 of a photocatalytic coating, a second layer 44 of a photocatalytic metal loaded metal compound coating, and a third layer 46 of a thermocatalytic coating and activating the layered catalytic coating 40 (page 5, lines 19 to 28, page 6, lines 27 to 30 and page 8, lines 7-11).

Dependent claim 35 depends on claim 28 and adds that the third layer 46 is a gold/metal oxide coating, and the method further includes the steps of forming a reactive hydroxyl radical, adsorbing contaminants onto the layered catalytic coating 40, oxidizing the contaminants with the reactive hydroxyl radical, lowering an energy barrier of oxidation of carbon monoxide with gold of the gold/metal oxide coating and then oxidizing the carbon monoxide (page 7, lines 12 to 23).

GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

- A. Are Claims 30 and 33 properly rejected under 35 U.S.C. 112, first paragraph?
- B. Are Claims 30 and 33 properly rejected under 35 U.S.C. 112, second paragraph?
- C. Are Claims 1-34 properly rejected under 35 U.S.C. 103(a) based on Reisfeld et al. (US 2003//0021720) in view of Kobayashi (US 6,368,668)?

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D. Is Claim 35 properly rejected under 35 U.S.C. 103(a) based on Reisfeld et al. (US 2003//0021720) in view of Kobayashi (US 6,368,668) and Appellant's Admission?

ARGUMENTS

A. Rejection of claims 30 and 33 under 35 USC 112, first paragraph.

The Examiner rejected claims 30 and 33 under 35 USC 112, first paragraph, as failing to comply with the enablement requirement. The Examiner states that the specification fails to describe the variable x in Mn_xO_2 , and the claimed invention is not enabling. Appellant respectfully disagrees.

The claimed invention is enabling. The variable x is the number of atoms of manganese in the compound Mn_xO_2 , and one skilled in the art would understand this. X is a variable that generally is open as to its possibilities. X denotes any number of atoms of manganese that could bond with two oxygen atoms. Manganese and oxygen only bond together at specific ratios. Therefore, if a compound includes two oxygen atoms, the number x can represent any number of manganese atoms that are needed to form a compound of manganese oxide including two oxygen atoms. The Examiner states on page 4 of the Final Office Action that x can be more than one number, whether the number is an integer or a fraction. However, atoms only bond as numbers that are integers and not fractions. Therefore, because of the bonding of manganese and oxygen together, one skilled in the art would know what numbers the variable x can be. For example, x can be 1 to form MnO_2 . However, this is only an example. The specification is enabling. Appellant respectfully requests that the rejection be withdrawn.

B. Rejection of claims 30 and 33 under 35 USC 112, second paragraph.

The Examiner rejected claims 30 and 33 under 35 USC 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject which matter Appellant regards as the invention. Appellant respectfully disagrees.

The claimed invention is not indefinite. The variable x is the number of atoms of manganese in the compound Mn_xO_2 , and one skilled in the art would understand this. X is a variable that

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generally is open as to its possibilities. X denotes any number of atoms of manganese that could bond with two oxygen atoms. Manganese and oxygen only bond together at specific ratios. Therefore, if a compound includes two oxygen atoms, the number x can represent any number of manganese atoms that are needed to form a compound of manganese oxide including two oxygen atoms. The Examiner states on page 4 of the Final Office Action that x can be more than one number, whether the number is an integer or a fraction. However, atoms only bond as numbers that are integers and not fractions. Therefore, because of the bonding of manganese and oxygen together, one skilled in the art would know what numbers the variable x can be. For example, x can be 1 to form MnO_2 . However, this is only an example. The specification is not indefinite. Appellant respectfully requests that the rejection be withdrawn.

C. Anticipation of Claims 1-34 based on based on Reisfeld et al. in view of Kobayashi.

Claims 1, 2, 4-12, 14-21 and 30

Claims 1-34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Reisfeld et al. in view of Kobayashi. Reisfeld et al. teaches a coating of titanium dioxide. The Examiner admits that Reisfeld et al. does not disclose a layered catalytic coating including a first layer of a photocatalytic coating, a second layer of a photocatalytic metal loaded metal compound coating and a third layer of a thermocatalytic coating. The Examiner states that Kobayashi discloses these features, and it would be obvious to employ these features in Reisfeld et al. The Examiner further states that the specification does not disclose the benefits of arranging each of the layers in the claimed order as compared to the generally and randomly applied layers as taught by Kobayashi, and therefore the claimed invention is obvious. Appellant respectfully disagrees.

The present invention is patentable and strikingly different from Reisfeld et al. in view of Kobayashi. As described by the claims, the present invention provides an air purification system including:

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a substrate; and

a layered catalytic coating applied on said substrate, wherein said layered catalytic coating comprises a first layer of a photocatalytic coating, a second layer of a photocatalytic metal loaded metal compound coating, and a third layer of a thermocatalytic coating.

[See Claim 1]. Claims 1-35 of the present invention all share these same or similar features. [See Claims 1-35]

The claimed invention is not obvious. Kobayaski does not disclose a layered catalytic coating including a first layer of a photocatalytic coating, a second layer of a photocatalytic metal loaded metal compound coating and a third layer of a thermocatalytic coating. Kobayaski only generally discloses a photocatalytic coating 2b of titanium dioxide or titanium dioxide including a metal or metal/oxide. Kobayaski generally discloses that "a plurality of different photocatalyst coating compositions may be provided followed by successive coating of the plurality of different photocatalyst coating compositions on the surface of the substrate." However, Kobayaski does not disclose any specific layers that form a coating 2b, including the claimed layers, and there is no suggestion in Kobayaski to employ the claimed layers to form a coating.

The claimed layers in the claimed order provide benefits that would not be obtained by generally and randomly applying layers on a substrate as disclosed in Kobayaski. Appellant has invented a unique layered coating that provides benefits over the prior art and which allows the coating to be tailored for a specific application. That is, the choice and the selection of the particular layers is inventive. Just randomly and generally applying layers to a substrate would not produce the effect of the claimed invention. There is no suggestion or teaching in Kobayaski to form the coating with the layers and order as claimed.

The Examiner also cited *In re Japikse* 86 USPQ 70, stating that "rearrangement of parts was held to have been obvious." In *In re Japikse*, claims to a hydraulic power press included features directed to a position of a starting switch. The Court held that there is "no invention in shifting the

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starting switch disclosed by Cannon to a different position since the operation of the device would not thereby be modified." That is, the Court held that moving the position of the starting switch was not a patentable features because moving the position of the starting switch would not have modified the operation of the device. As disclosed in the specification, each layer provides a different function. For example, titanium dioxide or metal oxide doped titanium dioxide are effective in oxidizing volatile organic compounds and semi-volatile organic compounds to carbon dioxide and water (paragraph 25). Titanium dioxide loaded with platinum is highly reactive with low polarity organic compounds (paragraph 32). Gold on titanium dioxide oxidizes carbon monoxide to carbon dioxide (paragraph 36). Manganese oxide/titanium dioxide decomposes ozone to oxygen (paragraph 43). Each of these different layers provide different functions. Therefore, if the layers in a coating were changed or randomly applied, the results produced by the coating would change. That is, the operation of the coating would be modified by changing or modifying the layers. *In re Japikse* relates to a case where operation of the device would not be modified by changing the position of the elements. The claimed coating would function differently if the layers were applied in a different order. The claimed invention is not obvious, and Appellant respectfully requests that the rejection be withdrawn.

Claim 3

The rejection of Claim 3 is separately contested from the rejection of Claims 1-34 et al. Claim 3 recites that the first layer is a metal compound loaded titanium dioxide coating, and the metal compound is at least one of WO_3 , ZnO , CdS , $SrTiO_3$, Fe_2O_3 , V_2O_5 , SnO_2 , $FeTiO_3$, PbO , Co_3O_4 , NiO , CeO_2 , CuO , SiO_2 , Al_2O_3 , Cr_2O_3 , and ZrO_2 . The Examiner admits that Reisfeld et al. does not disclose a layered catalytic coating including a first layer of a photocatalytic coating, a second layer of a photocatalytic metal loaded metal compound coating and a third layer of a thermocatalytic coating. Therefore, Reisfeld et al. does not disclose at least one of WO_3 , ZnO , CdS , $SrTiO_3$, Fe_2O_3 , V_2O_5 , SnO_2 , $FeTiO_3$, PbO , Co_3O_4 , NiO , CeO_2 , CuO , SiO_2 , Al_2O_3 , Cr_2O_3 , and ZrO_2 loaded titanium dioxide coating. Kobayaski also does not disclose this feature. Kobayaski discloses

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a method for producing a photocatalytic material. A photocatalyst coating composition includes a photocatalytic metal oxide (column 3, lines 48 to 67) including TiO_2 , ZnO , SnO_2 , SnO_2 , $SrTiO_2$, WO_3 , Fe_2O_3 and V_2O_5 . The photocatalyst coating composition can further include copper, silver, nickel, iron, zinc, platinum, gold, rhodium, vanadium, chromium, cobalt, manganese, tungsten, niobium, antimony, platinum group metals and oxides of the above metals, CUO_2 , AG_2O_2 , and molybdenum (column 5, lines 53 to 67). However, Kobayashi does not disclose, suggest or teach a layer including one of WO_3 , ZnO , CdS , $SrTiO_3$, Fe_2O_3 , V_2O_5 , SnO_2 , $FeTiO_3$, PbO , Co_3O_4 , NiO , CeO_2 , CuO , SiO_2 , Al_2O_3 , Cr_2O_3 , and ZrO_2 *loaded titanium dioxide* as claimed. Therefore, the references taken together do not suggest, teach or disclose the claimed invention. The claimed invention is not obvious, and Appellant respectfully requests that the rejection be withdrawn.

Claim 13

The rejection of Claim 13 is separately contested from the rejection of Claims 1-34 et al. Claim 13 recites that the third layer is applied on the substrate, the second layer is applied on the third layer, and the first layer is applied on the second layer. As stated above, neither Reisfeld et al. nor Kobayashi discloses a layered catalytic coating including a first layer of a photocatalytic coating, a second layer of a photocatalytic metal loaded metal compound coating and a third layer of a thermocatalytic coating. Kobayashi only generally discloses a photocatalytic coating of titanium dioxide or titanium dioxide including a metal or metal/oxide. Kobayashi generally discloses that "a plurality of different photocatalyst coating compositions may be provided followed by successive coating of the plurality of different photocatalyst coating compositions on the surface of the substrate." However, Kobayashi does not disclose any specific layers that form a coating, including the claimed layers, and there is no suggestion in Kobayashi to employ the claimed layers to form a coating.

The claimed layers in the claimed order provide benefits that would not be obtained by generally and randomly applying layers on a substrate as disclosed in Kobayashi. Appellant has invented a unique layered coating that provides benefits over the prior art and which allows the

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coating to be tailored for a specific application. That is, the choice and the selection of the particular layers is inventive. Just randomly and generally applying layers to a substrate would not produce the effect of the claimed invention. There is no suggestion or teaching in Kobayaski to form the coating with the layers and order as claimed. Applicant respectfully requests that the rejection be withdrawn.

Claims 22, 23 and 31

The rejection of Claims 22, 23 and 31 is separately contested from the rejection of Claims 1-34 et al. The claimed invention is not obvious. Reisfeld et al. does not disclose a layered catalytic coating. Kobayaski also does not disclose a layered catalytic coating including a first layer of a photocatalytic coating, a second layer of a photocatalytic metal loaded metal compound coating and a third layer of a thermocatalytic coating. Kobayaski only generally discloses a photocatalytic coating 2b of titanium dioxide or titanium dioxide including a metal or metal/oxide. Kobayaski generally discloses that “a plurality of different photocatalyst coating compositions may be provided followed by successive coating of the plurality of different photocatalyst coating compositions on the surface of the substrate.” However, Kobayaski does not disclose any specific layers that form a coating 2b, including the claimed layers, and there is no suggestion in Kobayaski to employ the claimed layers to form a coating.

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The Examiner also cited *In re Japikse* 86 USPQ 70, stating that “rearrangement of parts was held to have been obvious.” In *In re Japikse*, claims to a hydraulic power press included features directed to a position of a starting switch. The Court held that there is “no invention in shifting the

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starting switch disclosed by Cannon to a different position since the operation of the device would not thereby be modified." That is, the Court held that moving the position of the starting switch was not a patentable features because moving the position of the starting switch would not have modified the operation of the device. As disclosed in the specification, each layer provides a different function. For example, titanium dioxide or metal oxide doped titanium dioxide are effective in oxidizing volatile organic compounds and semi-volatile organic compounds to carbon dioxide and water (paragraph 25). Titanium dioxide loaded with platinum is highly reactive with low polarity organic compounds (paragraph 32). Gold on titanium dioxide oxidizes carbon monoxide to carbon dioxide (paragraph 36). Manganese oxide/titanium dioxide decomposes ozone to oxygen (paragraph 43). Each of these different layers provide different functions. Therefore, if the layers in a coating were changed or randomly applied, the results produced by the coating would change. That is, the operation of the coating would be modified by changing or modifying the layers. *In re Japikse* relates to a case where operation of the device would not be modified by changing the position of the elements. The claimed coating would function differently if the layers were applied in a different order. The claimed invention is not obvious, and Appellant respectfully requests that the rejection be withdrawn.

Claims 24-27, 32 and 33

The rejection of Claims 24-27, 32 and 33 is separately contested from the rejection of Claims 1-34 et al. There is also no suggestion in any of the references to use three substrates each having a different coating as recited in claims 24-27, 32 and 33. The Examiner states that Reisfeld et al. discloses more than one substrate and that one skilled in the art would provide each of Reisfeld et al.'s substrates with a different coating to increase the photocatalytic oxidation. However, the Examiner supplies no evidence of this assertion. Appellant cannot respond without the evidence, and thus ask that holding be dropped or evidence supplied. Notably, the relevant question is not whether different coatings on different substrates has ever been done anywhere. Instead, the question is whether it would have been obvious to employ the features in the claimed environment. Clearly, it

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would not have been. Reisfeld et al. only discloses a coating 120 on filter elements 12, 14 and 16. Different coatings 120 are not disclosed on each of the filter elements 12, 14 and 16. Additionally, Kobayaski only generally discloses coatings, but does not disclose, suggest or teach using a different coating on each of multiple substrates. Neither reference discloses, suggests or teaches using a different coating on each of different substrates. Therefore, the references taken together do not disclose, suggest or teach the claimed invention. The claimed invention is not obvious, and Appellant respectfully requests that the rejection be withdrawn.

Claim 28, 29 and 34

The rejection of Claims 28, 29 and 34 are separately contested from the rejection of Claims 1-34 et al. Claims 28, 29 and 34 recite a method of purification including the steps of applying a layered catalytic coating on a substrate, wherein the layered catalytic coating comprises a first layer of a photocatalytic coating, a second layer of a photocatalytic metal loaded metal compound coating, and a third layer of a thermocatalytic coating and activating the layered catalytic coating.

The claimed invention is not obvious. Reisfeld et al. does not disclose a layered catalytic coating. Kobayaski also does not disclose a layered catalytic coating including a first layer of a photocatalytic coating, a second layer of a photocatalytic metal loaded metal compound coating and a third layer of a thermocatalytic coating. Kobayaski only generally discloses a photocatalytic coating 2b of titanium dioxide or titanium dioxide including a metal or metal/oxide. Kobayaski generally discloses that "a plurality of different photocatalyst coating compositions may be provided followed by successive coating of the plurality of different photocatalyst coating compositions on the surface of the substrate." However, Kobayaski does not disclose any specific layers that form a coating 2b, including the claimed layers, and there is no suggestion in Kobayaski to employ the claimed layers to form a coating.

The claimed layers in the claimed order provide benefits that would not be obtained by generally and randomly applying layers on a substrate as disclosed in Kobayaski. Appellant has invented a unique layered coating that provides benefits over the prior art and which allows the

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coating to be tailored for a specific application. That is, the choice and the selection of the particular layers is inventive. Just randomly and generally applying layers to a substrate would not produce the effect of the claimed invention. There is no suggestion or teaching in Kobayaski to form the coating with the layers and order as claimed.

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D. Obviousness of claim 35 based on Reisfeld et al. in view of Kobayashi and Appellant's Admission.

Claim 35

The rejection of Claim 35 is separately contested from the rejection of Claims 1-34 et al. Claim 35 is rejected under 35 U.S.C. 103(a) as being unpatentable over Reisfeld et al. in view of Kobayashi and Appellant's admission. The Examiner states that the references do not disclose the step of forming reactive hydroxyl radical and air that contains carbon monoxide.

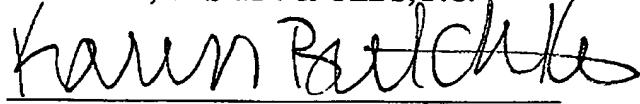
The Examiner states that Appellant admits that indoor air comprises carbon monoxide and that hydroxyl radical is formed when titanium dioxide is illuminated with ultraviolet light, and the claimed invention is obvious. Appellant respectfully disagrees. Claim 35 depends on patentable independent claim 28 and is allowable for the reasons set forth above. Claim 35 is not obvious because independent claim 28 is not obvious in view of Reisfeld et al. and Kobayashi. It is not obvious to provide a layered catalytic coating in Reisfeld et al. for the reasons set forth above. The claimed invention is not obvious, and Appellant respectfully requests that the rejection be withdrawn.

CONCLUSION

For the reasons set forth above, the rejection of all claims is improper and should be reversed. Appellant respectfully requests such an action.

Respectfully Submitted,

CARLSON, GASKEY & OLDS, P.C.



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Dated: September 7, 2006

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CERTIFICATE OF FACSIMILE

I hereby certify that this appeal brief is being facsimile transmitted to the United States Patent and Trademark Office, 571-273-8300 on September 7, 2006.


Amy M. Spaulding

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CLAIM APPENDIX

1. A purification system comprising:
 - a substrate; and
 - a layered catalytic coating applied on said substrate, wherein said layered catalytic coating comprises a first layer of a photocatalytic coating, a second layer of a photocatalytic metal loaded metal compound coating, and a third layer of a thermocatalytic coating.
2. The purification system as recited in claim 1 wherein said first layer is one of titanium dioxide and a metal compound loaded titanium dioxide.
3. The purification system as recited in claim 2 wherein said first layer is a metal compound loaded titanium dioxide coating and said metal compound is at least one of WO_3 , ZnO , CdS , $SrTiO_3$, Fe_2O_3 , V_2O_5 , SnO_2 , $FeTiO_3$, PbO , Co_3O_4 , NiO , CeO_2 , CuO , SiO_2 , Al_2O_3 , Cr_2O_3 , and ZrO_2 .
4. The purification system as recited in claim 1 wherein said first layer has a thickness less than 2 μm .
5. The purification system as recited in claim 1 wherein said second layer is a catalytically active metal supported on titanium dioxide.
6. The purification system as recited in claim 5 wherein said catalytically active metal is one of a metal alloy and an intermetallic compound supported on said titanium dioxide.
7. The purification system as recited in claim 5 wherein said catalytically active metal is a Group VIII noble metal.

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8. The purification system as recited in claim 7 wherein said Group VIII noble metal is one of rhodium, ruthenium, palladium, iridium, osmium, and platinum.
9. The purification system as recited in claim 5 wherein said catalytically active metal is one of silver and rhenium.
10. The purification system as recited in claim 1 wherein said second layer oxidizes low polarity organic molecules.
11. The purification system as recited in claim 1 wherein said third layer comprises gold on a metal oxide, and said metal oxide is one of titanium dioxide, mixed metal oxides including titanium dioxide, and titanium dioxide loaded with a second metal oxide.
12. The purification system as recited in claim 11 wherein said third layer oxidizes carbon monoxide.
13. The purification system as recited in claim 1 wherein said third layer is applied on said substrate, said second layer is applied on said third layer, and said first layer is applied on said second layer.
14. The purification system as recited in claim 1 further comprising a manganese oxide/metal oxide layer applied on said substrate, and said third layer is applied on said manganese oxide/metal oxide layer, said second layer is applied on said third layer, and said first layer is applied on said second layer.
15. The purification system as recited in claim 14 wherein said manganese oxide/metal oxide layer is manganese oxide and a promoter doped manganese oxide/titanium dioxide.

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16. The purification system as recited in claim 14 wherein manganese oxide/metal oxide layer decomposes ozone.
17. The purification system as recited in claim 1 further comprising a light source to activate said layered catalytic coating, wherein said layered catalytic coating oxidizes contaminants that are adsorbed onto said layered catalytic coating when activated by said light source.
18. The purification system as recited in claim 17 wherein said light source is an ultraviolet light source.
19. The purification system as recited in claim 17 wherein photons from said light source are absorbed by said layered catalytic coating, forming a reactive hydroxyl radical that oxidizes said contaminants in the presence of oxygen and water, and said reactive hydroxyl radical oxidizes said contaminants to water and carbon dioxide.
20. The purification system as recited in claim 17 wherein said contaminants are at least one of a volatile organic compound and a semi-volatile organic compound including at least one of aldehyde, ketone, alcohol, aromatic, alkene, and alkane.
21. The purification system as recited in claim 1 wherein said first layer, said second layer and said third layer are porous.

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22. A fluid purification system comprising:
 - a container having an inlet and an outlet;
 - a porous substrate inside said container;
 - a device for drawing a fluid into said container through said inlet, flowing said fluid through said porous substrate, and expelling said fluid out of said container through said outlet;
 - a layered catalytic coating applied on said substrate, and said layered catalytic coating includes a first layer of a photocatalytic metal oxide coating, a second layer of a photocatalytic noble metal loaded metal oxide coating, and a third layer of a thermocatalytic coating, and said third layer is gold/metal oxide; and
 - an ultraviolet light source to activate said layered catalytic coating, and photons from said ultraviolet light source are absorbed by said layered catalytic coating to form a reactive hydroxyl radical, and said reactive hydroxyl radical oxidizes contaminants in said fluid that are adsorbed onto said layered catalytic coating when activated by said ultraviolet light source to water and carbon dioxide in the presence of water and oxygen.
23. The fluid purification system as recited in claim 22 wherein said fluid is air.
24. A purification system comprising:
 - a first substrate having a first coating of one of titanium dioxide and metal compound/titanium dioxide;
 - a second substrate having a second coating of metal/titanium dioxide; and
 - a third substrate having a third coating of metal oxide/titanium dioxide.
25. The purification system as recited in claim 24 wherein said first coating is metal compound/titanium dioxide, said second coating is gold/titanium dioxide, and said third coating is manganese oxide/titanium dioxide.

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26. The purification system as recited in claim 24 wherein a metal oxide of said metal oxide/titanium dioxide is at least one of WO_3 , ZnO , $SrTiO_3$, Fe_2O_3 , V_2O_5 , SnO_2 , $FeTiO_3$, PbO , Co_3O_4 , NiO , CeO_2 , CuO , SiO_2 , Al_2O_3 , Cr_2O_3 , and ZrO_2
27. The purification system as recited in claim 24 wherein said third substrate is distal to an inlet of said purification system, and said first substrate and said second substrate are proximate to said inlet of said purification system.
28. A method of purification comprising the steps of:
applying a layered catalytic coating on a substrate, wherein said layered catalytic coating comprises a first layer of a photocatalytic coating, a second layer of a photocatalytic metal loaded metal compound coating, and a third layer of a thermocatalytic coating; and
activating said layered catalytic coating.
29. The purification system as recited in claim 1 wherein said substrate is a honeycomb.
30. The purification system as recited in claim 2 wherein said first layer is a metal compound loaded titanium dioxide coating and said metal compound is Mn_xO_2 .
31. The fluid purification system as recited in claim 22 wherein said porous substrate is a honeycomb.
32. The purification system as recited in claim 24 wherein each of said first substrate, said second substrate and said third substrate are a honeycomb.
33. The purification system as recited in claim 24 wherein a metal oxide of said metal oxide/titanium dioxide is Mn_xO_2 .

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34. The method as recited in claim 28 wherein said substrate is a honeycomb.
35. The method as recited in claim 28 wherein said third layer is a gold/metal oxide coating, the method further including the steps of:
 - forming a reactive hydroxyl radical;
 - adsorbing contaminants onto said layered catalytic coating;
 - oxidizing said contaminants with said reactive hydroxyl radical;
 - lowering an energy barrier of oxidation of carbon monoxide with gold of said gold/metal oxide coating; and
 - then oxidizing said carbon monoxide.

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EVIDENCE APPENDIX

None

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RELATED PROCEEDINGS APPENDIX

None

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